Abstract— Focusing on aiding the calculation of short
circuit currents and equivalent circuit impedances in Medium
Voltage Installations, according to IEC 60909, usually a time
consuming task, a Software Tool was developed in Excel.
IEC 60909 is introduced and its methods and formulas
are explained, as far as possible.
The approach to the problem is carefully explained and
the decisions made throughout the development are justified.
Some results are shown to prove the quality of the Tool.

Keywords— Short Circuit, Electrical Installations, IEC 60909

I. INTRODUCTION

In the past few decades electrical project has been
standardized. In Europe, International Electrical Commission
plays this role and as a result IEC 60909 was born. This
document tries to define methods to accurately calculate short
circuit currents.

A trend to more and more powerful computers can also be
seen and it was a matter of time until an attempt to use
machines to calculate such currents. Simultaneously, a
widespread of Personal Computers and the dominant position
of Microsoft worldwide allowed MS Excel to be one of the
most used tools in fields such as Finance, Economics or
Engineering. Its resources and capabilities are regarded as
extremely useful.

As a result of this Mater Thesis, a software tool to calculate
different short circuit currents in Excel is to be developed. The
decision of developing on this platform is justified by its
widespread use.

The main goal behind this program is to help the user
calculating short circuit currents in Medium Voltage
installations. And to achieve this, an intuitive user interface is
to be designed, using Visual Basic for Applications VBA.

In the very end of running this application and as a result,
the values of the Initial Symmetrical Short circuit current, the
Peak Current, the Breaking Current and the Thermal Current
are expected.

II. DEFINING THE PROBLEM

A. Typical Structure

The objective of this Tool is to calculate, in each electric
bus, the different short circuit currents. To do so, a typical
electric network needed to be chosen:

As one can see in the previous image, the buses 1 and 4 can also be
supplied by generators.

Figure 1 - Typical Electric Installation

This network is supplied by the Public Network and
eventually by Generators. To maximize the number of cases
that this program can simulate, four of the six electric buses
can be switched on or off, according to the users will. Each of
this electric bus feeds up to three electric motors. As one can
see in the previous image, the buses 1 and 4 can also be
supplied by generators.

An example of Network configuration:
B. Excel Characteristics

As previously said, Excel is one of the most widespread computer tools ever and its resources and capabilities are attractive to develop this kind of application.

Among all the characteristic of this program, the one that allows the optimization and enhancement of its resources is the fact of using a programming language specific to this platform, Visual Basic for Applications (VBA). This important fact brings us to a list of both qualities and defects:

- Macros are a set of tasks that the user may not have to repeat by recording them;
- Userforms are extremely useful when trying to interact with the user. They also allow some calculations to be executed immediately when the user is filling this form;
- A disadvantage of using Excel to develop an application to deal with electric circuits is the fact that complex numbers are not so easily understood by VBA, meaning that this numbers are considered to be strings. This will bring some problems throughout the development;
- One of the disadvantages of being so widespread worldwide is that it also has to deal with different numerical systems. In the UK or the USA the “dot” is used to decimals and in Europe the “comma” is used. This is also a source of trouble, especially when adding this one to the previous;
- An incredible resource of Excel is its Spreadsheet with all its graphical resources, like Shapes and Graphs that allow the user to immediately understand the program. But this interaction between the Spreadsheet and the VBA code can cause some trouble, especially due to the variable types of data.

III. EXPLAINING THE APPROACH

To solve this challenge, the strategy is the following: first, the definition of the network; then, the data introduction; after this, the algorithms need to be applied and finally the results will be shown. Visually:

A. Network Definition

This stage of developing an user interface in Excel is quite challenging. The grounding concept to build an intuitive interface is the following:

The simple On/Off button created is similar to those used on smartphone apps but is not common to see it when developing on VBA.

With this concept and with the goal of designing an intuitive network, using Excel Shapes also, the following user interface was developed:
This Interface allows the user to simulate a variety of cases and this implies that the structures on which this Interface is based are prepared for that. This will be explained ahead.

B. Data Introduction

Alongside with the exact definition of the electrical installation, the network, the program needs the user to introduce the specifications of the electric devices, the data. To do so, a set of Userforms was developed so that it would be easy for the user to understand what was being asked and when and how to introduce it. As an example, by clicking on one of the electric motors, the following userform will be shown:

![Electric Motor Userform](image)

As one can see, some specifications are requested in order to calculate its electric impedance. When determined this impedance, the result is presented to the user:

![Element Impedance](image)

C. Data Structures

In order to allow so many changes by the user in this program, a reliable data structure needed to be developed. Recalling the goal of this program that is calculating different short circuit currents it is then mandatory calculate equivalent circuit impedances. Illustrating with an example:

![Small Example](image)

The goal is to calculate equivalent circuit impedances seen by both bus 1 and bus 2. Bearing this in mind, a graph was designed and algorithms developed to work on this structure. The equivalence is the following:

![Equivalence between the Example and the Graph](image)

In the case of this program, a significantly bigger structure is required, but the strategy is the same:
And the same graph “seen” from the Node 1:

To work on this structure, two algorithms were developed: one to change the graph according to a given point, and a second one to calculate equivalent circuit impedances, based on the graphs. As an example, it is intended to change the circuit “seen from” bus 1 and calculate the impedance:

D. Implementation of IEC 60909

According to this standard, four different short circuit currents have to be determined, namely: Initial Symmetrical Short Circuit, Peak Current, Breaking Current and Thermal Current.

1) Initial Symmetrical short circuit current

This value is the most important one, because all the others depend on it and to calculate this current, the already explained concepts were used and the value calculated as follows:

2) Peak Current

Peak current is the maximum value that the short circuit can achieve and to determine this current some additional calculations are necessary and some algorithms are used more than once. As follows:

3) Breaking Current

The calculation of the breaking current is more complex because it introduces the concept of a short circuit near or far from the Generator. So:

And with this determined, one can calculate the braking current value as follows:

4) (Equivalent) Thermal Current

Finally, the calculation of the Thermal current which depends on two factors, namely “m” and “n”. So the calculation follows:
IV. CONCLUSION

The developed Tool tried to have the wider applicability possible, with a large number of cases that it can treat. Even though the structure could have been another the adopted solution allows a tradeoff between flexibility in the network geometry and precision on the calculations performed.

Probably Excel is not the ideal platform for this kind of program because of both the difficulty of dealing with complex numbers and also the complexity of developing user interfaces.

Regarding the precision of the calculations involved, an attempt to avoid approximations was made and it was only done when it couldn’t be avoided.

Analyzing the usefulness of the developed Tool, It is of limited applicability when compared to the commercialized and professional alternatives, as expected.

A suggestion of future work or development is the application of these algorithms to bigger networks, with more elements and eventually, on another platform.

REFERENCES